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ABSTRACT

The study was conceptualized within the social critical perspective to investigate the effect of gender and socioeconomic background on the students' classroom communication and the hidden curriculum. Year 9 mathematics classrooms in two single-sex private schools were observed during the course of learning one chapter from the same textbook. One class was in a low socioeconomic girls' school and the other in a high socioeconomic boys' school. Being an exploratory study, these two types of schools were chosen to maximize differences between them. Constructs from sociolinguistics were employed to investigate the variation in discourse between the two classes. Comparison of the context of discourse in mathematics in the two classrooms showed that, even though the teachers and students were engaged in working from the same textbook, the actualized curriculum was quite different in both classes. The class in the boys' school was developing mathematics as a highly formal field of study, stressing mathematical structures, concepts, and language, whereas the class in the girls' school was developing mathematics as a set of skills or rules. Contains 40 references. (MKR)

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SOCIAL CONTEXT IN MATHEMATICS CLASSROOMS: SOCIAL CRITICAL AND SOCIOLINGUISTIC PERSPECTIVES

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SOCIAL CONTEXT IN MATHEMATICS CLASSROOMS: SOCIAL CRITICAL AND SOCIOLINGUISTIC PERSPECTIVES

This study is part of the Social Context Project at the Centre for Mathematics and Science Education, in Brisbane, Australia. The study has been conceptualised within the social critical perspective to investigate the effect of gender and socioeconomic background of the student on the construction of classroom communication and the hidden curriculum. Two classes from a low socioeconomic girls school and a high socioeconomic boys school were observed while teaching the same chapter from the book. Constructs from sociolinguistics were employed to investigate the variation in discourse between the two classes.

Since the mid-sixties, the mounting evidence of the failure of many school compensatory programs to raise the condition of minorities and the disadvantaged has raised questions about the role schools play in reproducing social inequalities. Bowles and Gintis (1976) argued that schools play a primary role in preparing students from different social backgrounds to meet the needs of an unequal society. This position has been widely supported in the literature. However, the theory of correspondence between the power relations in the work force and in school has been criticised for presenting a deterministic view of the role of schools in reproducing inequality. Further, it does not pay due attention to forms of contradictions within the school system itself and to the role of resistance and contestation exhibited by students (Apple, 1980, 1981; Giroux, 1983; Willis, 1977). Similarly, the concept of hegemony (Gramsci, 1971) as the process by which the dominant classes of society use ideology to impose their values on subordinate groups has been considered more appropriate to study the functioning and role of schools.

Increasingly, the role of school mathematics in promoting and legitimising the reproductive nature of schooling is being questioned. The pioneering work of Anyon

(1981), in the early eighties, has demonstrated the variation in curricula as a function of the socioeconomic background of students. The extensive literature on girls and mathematics (eg., Burton, 1986, 1990; Fennema & Leder, 1990; Leder, 1992; Willis, 1989) highlights the role of gender in determining opportunity to participate in higher mathematics. Mathematics appears to have a formidable role in reproducing ideologies, a role that is made more powerful because of the notion of objectivity that surrounds it and masks its hegemonic function. Bishop (1988) argued that mathematics is neither culture free nor value free. The function of school mathematics as a behavioural badge of eligibility for the privileges of society has often been noted (Stake & Easley, 1978; Fennema & Leder, 1990). Willis (1989, p. 35) argued that mathematics "is not used as a selection device because it is useful, but rather the reverse". Harris (1991) added that this role of school mathematics to differentiate students on their ability and their access to opportunity started last century and still "lingers at an almost unconscious level that reifies it as something fundamental and immutable. It still dominates both the historical view of mathematics as a discipline and the deliberations of curriculum planners and it still has nothing to do with intellectual ability" (p. 9).

Research in the social context in mathematics education has dealt with these and related issues. This paper reports on some findings from the Social Context Project conducted at the Centre for Mathematics and Science Education in Queensland, Australia. The project, conceptualised within the tradition of critical sociology, was designed to investigate: the role of teachers' perception of the needs and ability of their students in their modifying the prescribed syllabus; the role of interactions in the classroom for mediating these perceptions; and the effect of gender and socioeconomic background of students on teacher beliefs and classroom interactions.

Before discussing some findings from the pilot study of the project, we will position the perspectives adopted in this Project with respect to other research in the social context of mathematics education. We shall do so by offering a model that may be used for categorisation of research in the area. Secondly, we will discuss some aspects of the sociosemiotic perspective on language development and use that assisted

in the analysis of the data in this study. At the conclusion of the paper, we will reflect on the research findings and on the benefit of using the multiple perspectives in illuminating aspects of the social context of mathematics education.

Alternative Conceptualisations of the Social Context

Research into the social context of mathematics is very diverse in theoretical perspectives adopted, questions addressed, and methodologies employed. It is not the intention here to review the research on the social context. Bishop and Nickson (1982) presented such a review of studies conducted in the seventies; Atweh, Cooper and Kanes (1992) reviewed Australian research on social context in the period 1988-1991; and Growus (1992) included at least four chapters on studies related to the social context on mathematics education. From these reviews, it is possible to identify at least three alternative conceptualisations of the social context and its role in mathematics education. In presenting these conceptualisations we are aware that any categorisation of research is at best ambitious and at worst dangerous. We do not claim that different research studies fall neatly into one or another of these conceptualisations. Rather, specific research questions reflect different understandings of the nature and the role of contextual factors. Further, we do not claim that any of these conceptualisations is privileged in any way over the others. Each conceptualisation gives rise to certain type of questions and yield useful findings. In the following brief discussion of the three conceptualisations, we will present examples of the different questions that rise within the different perspectives and, in particular, we will pay special attention to the role of the language in mathematics education.

The first conceptualisation regards the social context as a collection of **variables** that affect performance. Performance is defined in its widest sense to include attitudes and participation. Variables could be fixed factors, such as gender, or conditions subject to manipulation, such as classroom climate, teaching style, or the curriculum. Examples of research questions that may arise within this approach are: what are the effects of gender on achievement, ability, or learning style in mathematics; do students from

different social backgrounds participate equally in higher mathematics; what specific problems do minorities have in learning mathematics; are there variations in the frequency and type of interactions between teachers and different groups of students; how do different types of students attribute their success and failure and how is that related to success in mathematics. Concerns about language in mathematics education from this perspective might be along the lines: what mathematics language is appropriate for effective teaching; what problems arise in the development of the formal language of mathematics; are there gender differences in preferred mode of information presentation. Methods likely to be used to study these questions include experimental designs, correctional studies, and check-list classroom observation systems.

The second conceptualisation regards social contexts as complex and dynamic **settings** that give rise and meaning to performance. These settings are studied to determine what aspects of them give rise to a particular type of mathematics or behaviour. Research questions that may be posited from this approach include: what types of mathematics evolved in different cultures and different social settings; what constitutes ethnomathematics to certain groups of students; what are real world problems in mathematics; what meanings do teachers and students make of classroom interactions and activity; how is mathematics constructed as a male domain; what programs are successful to teach mathematics to students of low socioeconomic backgrounds. In terms of the role of the language in mathematics, the concerns may be along the following lines: how does mathematics knowledge evolve in bilingual bicultural contexts; what is the relationship between the natural language of the child and the language of mathematics. Methods likely to be used to study these questions include ethnographic interview, systematic and non-systematic observation, and action research.

The third conceptualisation regards the social context itself as an **object of investigation**. In this approach, the variables studied in the first category (eg., ability, knowledge, gender) are taken to be socially constructed by participants rather than as givens. Settings studied in the second approach are critically analysed in terms of

structure, values and power relationships. The emphasis in this approach is on the processes by which members of a society are enculturated into different settings and the contradictions within or between the different settings. Research questions that may be posited from this approach include: how is ability in mathematics constructed in the classroom and how it is used to differentiate between different groups' access to knowledge; how is the curriculum in mathematics modified to suit the perceived needs and abilities of different groups of students and how this modification itself creates the needs and abilities; what contradictions exist within the mathematics classroom. Language, according to this approach is perceived not only as means of developing knowledge, but also as means of transmitting the culture that give rise to mathematical knowledge. In terms of the role of the language in mathematics, the concerns may be along the following lines: how is the social context of mathematics mediated to the learner through interactions with others. Methods likely to be used to study these questions include ethnography, naturalistic observation, sociolinguistic discourse analysis, and critical analysis.

This study employs the third conceptualisation of the social context and uses an alloy of social critical sociology and sociolinguistics concepts to analyse the data. This approach leads to a conceptualisation that fits closely with the backgrounds and mindframes of the researchers involved (McRobbie & Tobin, submitted).

We view the mathematics classroom as a place where the teacher and students socially construct an interactive environment with the goal of promoting learning. We view this process of construction as being actuated primarily through the face-to-face discourse between participants. The purpose of this study is to examine how this discourse constructs different mathematics curricula, especially as a function of gender and socioeconomic background of students. Specifically, this study seeks to examine the following questions:

1. How do teachers' perceptions of their students' ability and needs affect the actualised curriculum in the mathematics classroom?

2. How are teachers' perceptions affected by the gender and socioeconomic background of students?
3. How are these perceptions mediated by classroom discourse?

Sociolinguistics in the Study of Context

This study was conceived from concerns about issues identified by the social critical sociology. It posited the classroom as a crucial context in which students undergo the process of socialisation into the mathematics culture. It is recognised that face-to-face communication between teacher and students has primary importance in constructing the social context in classrooms (Green, 1983). In this paper, we have adopted sociolinguistic methodology (Bleicher, 1994; Florio-Ruane, 1987) as the appropriate analytic system for examining social critical questions arising in classroom discourse. Aligned to the research questions, we employed a specific school of sociolinguistics, namely sociosemiotics, as formulated in the writings of Michael Halliday (1973,1974, 1978 Halliday & Hassan, 1989). According to this view:

> language is the main channel through which the patterns of living are transmitted to [the individual], through which he[/she] learns to act as a member of 'society'- in and through the various social groups, the family, the neighbourhood, and so on- and to adopt its 'culture', its methods of thought and action, its beliefs and its values. [Brackets added here]. (Halliday, 1974, page 4).

The child is "socialised into the value systems and behaviour patterns of the culture through the use of language at the same time that he[/she] is learning it" (page 21).

Halliday argues that in order to read a text, or listen to it, effectively and with understanding, we have to be able to interpret it in terms of three functions:

1a. understand the processes being referred to, the participants in these processes and the circumstances - time, cause, etc.- associated with them [EXPERIENTIAL];
1b. understand the relationship between one process and another, or one participant and another, that share the same position in the text [LOGICAL];

2. recognise the speech function, the type of offer, command, statement, or question, the attitudes and judgements embodied in it, and the rhetorical features that constitute it as a symbolic act [INTERPERSONAL];
3. grasp the news values and topicality of the message, and the coherence between one part of the text and every other part [TEXTUAL]. (Halliday & Hassan, 1989, page 45).

However, the full meaning of the text is only achieved by understanding its context. Halliday points out that the origin of the word context is CON-TEXT ie. 'with the text'. Con-text adds to the understand the text. Halliday presents a three components model to analyse the context of a text. The three context features of a text correspond to the three functions described above in a one-to-one relation, in a sense that each context is 'expressed' in the corresponding function and inversely each context predicts, to a certain degree the corresponding context. The three components of context are:

1. Field: refers to the institutional setting in which a piece of language occurs and embraces not only the subject matter but the whole activity of the speaker and participant in a setting[and we might add: 'and of other participants']...
2. Tenor: refers to the relationship between participants, ... not merely variations in formality ... but ... such questions as the permanence or otherwise of the relationship and the degree of emotional charge in it.
3. Mode: refers to the channel of communication adopted, not only between spoken and written words but much more detailed choices [and we might add:' and other choices relating to the role of language in the situation'] ... (page 34) [brackets in original]

METHODOLOGY

Setting

The Social Context Project. Since 1988, we have been working on a research project to study the effects of gender and social class on the teaching and learning of secondary school mathematics. We planned this project using three perspectives from educational literature: the social context of mathematics education, critical sociology and ethnographic research techniques. We based the project on the hypothesis that mathematics teachers conceive mathematics as a crucial subject for reproducing existing

social values and modify curriculum material according to the social class and gender of their pupils (Anyon, 1981; Atweh & Cooper, 1991; Cooper, 1988; Cooper & Meyenn, 1984; Cooper, Atweh, Baturo & Smith, 1993; Mellin-Olsen, 1987; Spender, 1982; Stake & Easley, 1978). The purpose of the project was to identify, describe and explain the differences that occur in classrooms of students with different gender and socioeconomic backgrounds. Of particular interest were differences in organisation of mathematics teaching within the school and teacher-student interactions within the classroom. Our concern was that these differences acted together to provide different learning opportunities for different groups of students.

Project Phases. We designed a series of field studies (Popkewitz & Tabachnick, 1981) in which we observed Year 9 mathematics classrooms, and interviewed pupils and teachers in state and private secondary schools which differed in the gender and socioeconomic background of their pupils.

The project has involved three stages. In stage one, we studied Year 9 mathematics classrooms in two single-sex private schools: low socioeconomic girls' class and high socioeconomic boys' class. Being an exploratory study, these two types of schools were chosen to maximise differences between them. The two schools used the same mathematics textbook and the two classes were observed alternatively by two investigators, for two weeks, while the content of the same chapter was covered. After the observations, eight pupils, a cross-section of the class, the teacher, the mathematics coordinator and the principal were interviewed. In stage two, similar observations and interviews were made on Year 9 mathematics classrooms in four single-sex private schools: low socioeconomic class girls, low socioeconomic class boys, high socioeconomic class girls, and high socioeconomic class boys. This allowed differences due to gender or class alone to be teased out. Interaction effects between the two factors were also highlighted. In stage three, similar observations and interviews were made on Year 9 mathematics classrooms in four state secondary co-educational schools: unemployed class, working class, middle class, and professional class. This paper

discusses data from stage one. Another paper (Atweh & Cooper, 1989) discusses other data from the same two schools. Likewise, other papers discuss findings from stage two of the project (Atweh & Cooper, 1991; Cooper, Atweh, Baturo & Smith, 1993;).

The Two Schools

Data were obtained from single classrooms in two schools: a low socioeconomic girls school (Northside) and a high socioeconomic boys school (Cityview).

Northside. This was a new school (founded in 1971) of 400 girls in a working class suburb. It was not served by public transport, which limited the access of students to the school after school hours. There was a lack of parental involvement in the school. The school supported non-competitive sports and would have liked to support cultural activities (eg., dance, drama, music). The school presented the impression, explicitly and implicitly, that its aim was to develop caring mothers who could operate as reasonably knowledgeable consumers. A small percentage of Northside pupils went on to tertiary studies. Teachers considered less than 50% of the pupils capable of taking advanced mathematics in Year 10. Of the nine mathematics teachers in the school, three had no training in either mathematics or mathematics education at the tertiary level. No mathematics teachers were sole specialists; all taught other subjects as well. Although the administration and the teachers asserted that mathematics was an important subject within the school curriculum, Oceanview appeared not to value mathematics as highly as other schools. For example, the school cut mathematics time by 25% to increase time on a pastoral care subject. The main focus of the mathematics classes was to develop consumer society skills.

Cityview. This was an old well established school of 800 boys in an inner city area. It had a self selecting population and a several years long waiting list. It prided itself on the tertiary entrance scores it gained for its pupils (80% went on to university).

There was a strong orientation towards university, to the point where it was considered failure if a boy did not achieve a score sufficient to enter a prestigious course (eg., medicine, law or business) at a university. While the schools' stated aim was to develop leadership, and programs were in place to do this, many school activities appeared to be distorted by the dominant goal for all boys to gain the highest possible tertiary entrance score. The mathematics teachers were well trained. Most appeared to be mathematics specialists, teaching no other subjects. Many pupils completed two mathematics subjects in Year 12. Unlike Northside, few pupils chose social mathematics in Years 11 and 12 (and those that did were considered failures). There was extremely strong parental pressure on pupils to do mathematics and to do it well, even though the career choices of some pupils did not require much mathematics.

Data Collection

Instruments. In addition to audio taping the lessons and keeping field notes, we used two instruments to study the Year 9 mathematics classes: an observation schedule (Atweh & Cooper, 1992) based on that of Good and Brophy, (1987); and interview scripts for use with pupils, teachers and management. Results from trials of the classroom instrument can be found in Atweh and Cooper (1992). The interview scripts enabled the interviewers to probe the pupils', teachers' and administration's views and perceptions about each other's views, and about the role and importance of mathematics for the school and the students.

Procedure. Two schools were chosen that met the criteria of difference in gender and social class but used the same textbook series. Their management, teachers and pupils were approached for permission to undertake the study. A common topic from the text, graphing of algebraic equations, was chosen for observation. Classes at each school were observed for the period the topic was taught. During observation, field notes were taken, the classes were audio taped, and teacher-student interactions coded as per the schedule. After the observations were completed, the principal,

mathematics coordinator, teacher and eight students were interviewed. The students were chosen so that: (1) they possessed high and low attitudes to mathematics, as perceived by the teacher; and high, medium and low achievement as measured by their teacher; and (2) exhibited interesting patterns of participation within the classes observed (eg either too much or too little interactions).

Data Analysis

Fieldnotes and interview data were analysed for evidence of the school characteristics salient to examining gender and social background differences between students. This provided evidence to help answer the first two research questions.

The audio tapes of classroom lessons were analysed using sociosemiotic methodology (Halliday & Hassan, 1989). This involved making transcripts of the recordings and submitting them to discourse analytic methods. In these methods, transcripts were broken down into clause level communication units. This basic unit of analysis is defined as the minimal unit of talk that allows meaningful communication between participants. At this level, communication problems can be pinpointed and linked to conceptual topic development during a lesson. Thus, this analytic unit allows the data to be interrogated for questions of gender and social background bias in teacher-student discourse as it relates to successful engagement in learning opportunities of various mathematical topics. In the following section, the analysis of the data is discussed in four sections. the first section discusses the results from the teacher interviews while the other three sections address each component of Halliday's model of context to analyse data from classroom observations.

RESULTS AND DISCUSSION

Teachers' Views on Their Students

Although the main analysis considered here is of the data obtained from classroom observations, we claim that classroom data can only make sense if analysed

with respect to the context in which it is constructed. The information about the two schools discussed in the previous section is one source of data that informs us about the context of the interactions observed in the classroom. The second source is the teachers' beliefs about their students' abilities and needs. These beliefs assist us in giving meaning to classroom interactions. A more detailed discussion of the two teachers, their background and beliefs can be found in Atweh and Cooper (1989).

Ivor, the teacher at the boys school, perceived his students as having high ability in mathematics. "These kids are going to be mathematicians in the sense that they are going to be able to construct models and draw inferences from them whether it be in business or in the scientific field. That is basically where we have to head with our mathematicians." His idea of a mathematician was that, "he (*sic*) is not one who solves an equation but someone who can develop an equation to be solved". Yet in order to solve problems, these mathematicians require a certain amount of knowledge and skill. Hence, in his view, "drill and practice are still very important". This belief justified his teaching strategy of information transfer and "cut[ting] down student talk so that you get the information through".

Jeff, the teacher in the girls school, had a different perception of his students. "The class I've got here are more or less the ordinary middle of the road. Most of those [students] would be flat out going into tertiary studies." Although they "have an idea I'm never going to need mathematics in the future because all I want to do is selling or be a check out girl. ... That is fair enough, but they don't realise that maths is important to them making sure that they're not jipping the customer or if they are the customer they're not jipped". He said that the topics they were covering at the moment, linear functions, "aren't as important" for these girls, presumably because it was not useful for consumer transactions.

It is worthwhile to note that both teachers adopted a utilitarian approach to teaching mathematics. However, each teacher focused on a different motivation for learning mathematics. Ivor believed his students would use mathematics to pursue careers in science and business, while Jeff envisioned his students as using mathematics

more informally for everyday consumer transactions. This difference in the use of mathematics is aligned with Willis's (1977) distinction between the value of mental and manual labour/competence.

The teachers were asked if the gender and socioeconomic background of their students affected their teaching style. Ivor said that if he were in a girls school, while he would not modify the content he was teaching, he would need to modify his teaching style. In his experience, girls were more sensitive than boys. He felt that he would not be able to joke with the girls as he could with the boys. He believed that girls hold grudges for longer periods of time.

Jeff, on the other hand, said that, "girls seem to be more easily distracted if they do not know or see the relevance [of mathematics] whereas is probably easier to motivate some of the boys". He added, "I guess being a male you can see the relevance that [mathematical] functions play in boys world ... You can draw graphs of revs and things like that because boys would be interested in cars ... whereas being a male it is harder to figure out areas of interest or where things might be applicable to girls."

Differences in the Field of Discourse

Both classes were teaching the same content in algebra, review of the Cartesian coordinates and plotting of linear functions. Both classes were teacher controlled. Although students in both classes had a chance to work individually on exercises from the book, whole group was the primary mode of instruction. Both teachers conducted lessons largely by engaging in a series of question-answer dialogues with students. However, a closer look at the classroom interactions revealed differences in the way the curriculum was actuated. These differences were, in the main, consistent with the teachers' beliefs about their students' abilities and needs.

Ivor presented rigorous definitions of the concept of a function in the following words, which were both spoken and written on the chalkboard:

Domain: numbers where we get the x (independent variables)

> Range : numbers where we get the y (dependent variables)
> Set of ordered pairs is a function iff for a value of x there is one and only one value of y.

He then presented an algorithmic version of the definition for determining if a relation was a function. Dealing with the same concept, Jeff introduced the definition through the algorithm. In all his definitions, Jeff attempted to give many examples and counter examples of a concept, and assisted students to generalise a pattern. He used these patterns as definitions.

Further, Ivor stressed the convention nature of mathematics. In dealing with the coordinate system, he asked the students why it was essential that the *x* coordinate always came first. Jeff's explanation of the same rule was " [since we say] x, y, z then x comes in first, therefore the *x* coordinate comes first". Once again the justification was presented an a rule-of-thumb to remember the order rather than a rational argument.

Another difference between the classes occurred in practical applications to everyday situations. At the end of his first class, Ivor reminded the students of the work that they had done on the pendulum in the science class as an example of functions. As homework, he asked the students to perform an experiment by varying the length of the pendulum and measuring its period. Students were asked to tabulate the results and graph them. At another time, to justify the need in mathematics to differentiate between functions and non-functions, he used an example from science.

> This morning in science we were talking about classification of plants. We said that some [types] have some properties, and [other types] have other properties. Here we have a relations: we have functions and non functions. It is just a classification. You may wonder why do we need to classify anything. It helps us to analyse a particular area.

Jeff's only reference to everyday situations came much later in the topic. At the end of the first week, students were plotting some non-linear functions and joining the points with a straight line. He drew attention to the fact that:

> Last year Mrs. Stanley, in geography has done with you climactic graphs ... Remember something like this: we have a grid and you plot the temperature on the bottom and the rain fall on top. You just joined them with a smooth curve and not a straight line ... So mathematics, science and geography are all the same sort of concepts.

The use of this example was not intended to relate to a practical application, but rather, to illustrate a rule, that points that do not fall on one line should not be joined by a straight line.

Hence, although the two classes were dealing with the same topic, and in rather similar ways, the hidden curriculum in both classes was quite different. In Ivor's class, mathematics was presented as a formal system, while in Jeff's, mathematics was based on generalisations and rules of thumb. Ivor stressed the reasons behind conventions, while Jeff presented conventions as rules of a game. Finally, Ivor presented mathematics as meaningful activity related to the real world, while Jeff presented mathematics as a set of rules to manipulate symbols. The point is not which approach was more valid or valuable, or which teaching style was more effective or relevant. Rather, the differences noted here were due to connections between teacher beliefs about their students and their manner of instruction. Ivor presented mathematics that he perceived would be needed for higher studies in mathematics, while Jeff was teaching mathematics that was "not very useful" for his students. Ivor was introducing his students into the culture of formal mathematics, while Jeff was introducing his students into a culture of "following the rules".

However, in both classes there were elements of the counter-culture. Although Ivor stressed understanding and formalism in his class, some students were obviously not comfortable with their understanding. On one occasion, after only a few attempts at explaining, Ivor said, "[we] got to a stage now where it is a definition, and that's all it is. It's a definition. If you don't understand the definition, you've got to learn the definition. That's it." Understanding seemed to be a luxury that was useful but not essential to learning. Further, Ivor's conception of a mathematician as someone (a male) "who writes equations to solve problems", and not as an inventor of models, was apparent in

his teaching. The students in his class did not engage in any open-ended activities. The class was topic and content oriented. Students spent a lot of their time going through routine exercises to develop "the skills and concepts needed for successful problem solving".

Similarly, Jeff's attempts at helping students discover patterns from examples, and build definitions from these patterns, apparently resulted in sending mixed messages to students. Students were invited to participate in the process of developing mathematical concepts, yet these acts of discovery lacked meaning. In the final analysis, this resulted in rules rather than concepts. The avoidance of formal mathematics may have made it more accessible to some students, yet it also resulted in an avoidance of a style of mathematics that is required for higher mathematics.

Differences in the Tenor of Discourse

Several researchers have investigated the differential ways in which teachers interact with students of different genders and different socioeconomic backgrounds (Leder, 1990; Willkinson & Marrett, 1985). This analysis will compare the two classes as they differ in the tenor of teacher-student interactions.

Both classes were similar in some aspects of tenor. For instance, most of the teaching was whole group, the teacher providing explanation and worked examples, and students practising solving examples from the book. Students from both classes were invited to participate in the developing of ideas by a series of directed questions from the teacher, who in turn provided feedback to their answers. There were some important differences as well.

Ivor believed that most of his students were university bound. One of his goals was to nurture independence in student self-assessment and achievement. Ivor considered this to be a useful prerequisite skill for higher education. This was reflected in the way he interacted with his students. While working on the exercises from the textbook, Ivor expected his students to check their own work. He was quite sarcastic when a student asked him to check their work for them. "You have the answers in the

back of the book, check it your self." "Your are a big boy now, you do not need me to check your work." Jeff had a different attitude towards student work. He corrected the mistakes that students were making by discussing them on the blackboard. He provided further examples and repeated the rules "for those who are still experiencing problems". Messages in the two classes were clearly different. In Ivor's class, students were challenged to engage in checking their own progress, while in Jeff's class, students were provided with an atmosphere of support and readily available assistance to deal with their difficulties.

Another difference in the tone of both classes was the general atmosphere in the classroom. Ivor conducted a class that gave the feeling of a battleground, a field of contestation between students and teachers. Several times in the lesson students complained, "I do not understand this", and were not hesitant to say, "I still do not understand". When the Ivor was discussing the classification of relations into functions and non functions, a student complained "What is the practical use of studying that." When the teacher said "it is a mathematical use and solely that", the student insisted "what use is that?" Also noticeable in the class was the use of sarcasm by the teacher. Sarcasm was used in several places in the classroom: when students asked an apparently silly question; when a student was not paying attention; when a student was disrupting the class. The affect of sarcasm can only be understood in the context of the situation in which it arose. The teacher's sarcastic comments were not taken by the students as a put down. The atmosphere of contestation, either in challenging the teacher for more information or in forms of disruptive behaviour, did not subside in the class as a result of these comments. Rather, they were understood as demands for attention, but also as a means of establishing an atmosphere of equality and reciprocal privilege with the teacher. Students responded to these comments by laughing or by sarcasm of their own:

> The teacher: Have you finished your chewing gum yet? You can go and put it in the bin. Is it one of the school rules around here that your are not allowed to have chewing gum in the school?

The offending student: I have not read it anywhere
Another student: (Opens a book at random) Rule thirteen, Alcohol and chewing gums are allowed.... (Class bursts in laughing).

Jeff had a different way of interacting with his student. He was very formal and serious with his students. He was firm in his expectations of and demands for attention and co-operation, yet he was noticeably polite in his interactions with the girls. To get the attention of some students, he would often say, "excuse me there, are you all right". He consistently called girls by their first names, and never reprimanded anyone for a wrong answer. The messages from the two classes were quite different. They were consistent with stereotypes that boys are independent, tough and rebellious, while girls are dependent, fragile and obedient.

A further difference between the two classes could be seen in the positioning of the human agency with respect to mathematics knowledge. It is illustrative here to quote the two teachers at length.

In this first quote, Jeff was teaching the plotting of inequalities. He had taken an example of $y<x$. Without any justification, he said, "how about doing this one first $y=x$?" He then proceeded to plot the linear function and chose several points on the plane, some on the line and some not.

> So we have a Cartesian plane with points everywhere. Now, [there are] some important things to remember. What I have done here is the equation $y = x$. And, we [have] seen the quadrant and [have] see[n] whether the points lie on the line. [This was] a quick revision of the things we have done these two weeks. So how is this going to help us in graphing inequation? Most of you are thinking this. Very simply if we have this (points to $y=x$) and this (points to $y<x$) they are identical. The only difference is this here: the sign (points to the = and the < signs). And if you remember the time when we were solving inequations, I said to you to solve them exactly the same way as you would with equations. So if we had, $5 = x+4$ and worked that out, and then we had $5<x+4$, I said to you to solve these exactly the same way as [you would] with the equal sign. So that is exactly the same procedure we are going to do in graphing inequations. We are going to graph them the same way as we graph a normal equation. There are a couple of exemptions. When we have a symbol < or > we are going to use a dotted line. (teacher writes):

Summary: 1) if symbol < or > use a dotted line
2) only time to use heavy line is if we
have <=
or >=

There are several things to notice about this exposition. First, the mathematical language was not exact or complete. Secondly, every sentence had one personal pronoun. This sample was quite representative of the style of talk that Jeff engaged in with his students. No sentence had a mathematical term as its subject. Mathematical knowledge was not presented as an abstract content that was separate from what people do. Lastly, the role of the first person pronoun was interesting. The "we" indicated a group ownership of the example and the procedures to be adopted. However, the two references to "I said to you" refer to a rule that students were to follow, but the rule was given without an explanation. This was not the only such construct that appeared in Jeff's talk. When students were connecting plotted points, obtained from a quadratic equation, by straight lines, he said.

> Now some of you have joined the points with a ruler to get a V shape. Now there is nothing wrong with that but I want to tell you that from now on when you get something like that do not join them with a straight line. Join them with a smooth curve.

No additional information is given. Let us compare this with a passage from Ivor's class.

> T: Take out your homework form last night. You were asked to do numbers. 6,7,8,9,12,14,16. You are asked to, first of all to state the domain for each of those graphs that were drawn, then you were asked to state the range, and then you were asked to state if it was a function or not. ... (Teacher writes on board and reads out loud):
>
> Domain: numbers where we get the x(independent variables)
> Range : numbers where we get the y (dependent variables)
>
> *(Teacher asks for help from students to name variables)*

> Then we end up with [a] set of order[ed] pairs. (writes (x,y)) ordered pairs x,y. (says and writes)
>
> Set of ordered pairs is a function iff (what ...)for a value of x there is one (not one, but one) and only one value of y.
>
> It is important to say one and only one. We can not have zero. There must be a value, for every x there must be a value of y, and there must be only one value of y.

In contrast to Jeff, Ivor used proper and rigorous mathematical language. Also, in contrast to Jeff, Ivor used much fewer first and second person constructs, thus giving the impression that mathematics was an objective discipline that had given truths.

Differences in the Mode of Discourse

The third contextual feature of the discourse occurring in the two classrooms is that of mode. If the field describes what is going on in terms of meaning of activities and the tenor describes the roles and relationships of participants, the mode could be described as interpreting how the participants accomplish these activities through the nuances of language used.

Two excerpts were chosen, one from each school, involving the same subject content. Teachers in each classroom were covering the same homework problem set. The discourse involved both written and verbal texts. The written text included the students' written homework papers, the textbook, and the teacher's writing on the chalkboard. The verbal text was primarily dialogue between the teacher and students, with sections of teacher monologue that was generally didactic in nature with the aim of checking homework problems and correcting any misunderstandings.

The following excerpt, from Cityview School, took place about ten minutes into the day's lesson. The teacher, Ivor, had been going over the homework set from the night before. The goal of the lesson was to help students begin to understand how to determine if an equation represented a function from examination of the x and y values.

This excerpt is in two segments. In the first (Lines 01-22), a student, Brett, was having trouble understanding Problem 9 and was asking the teacher for help. The interaction was interrupted by a distraction from the main lesson involving a student dropping a piece of chalk on the floor and the teacher reprimanding him. In the second segment (Lines 36-47), the Brett was continuing his dialogue with the teacher over his misunderstanding of Problem 9. In the following transcript "..." signifies a pause in the verbal discourse, underlined words mean the speaker put extra stress on them, "..... (interrupted)" indicates that the speaker on that line interrupted or overlapped the previous speaker, and the words begin at the point below at which this interruption took place.

01	s	(raises his hand to be called)
02	t	yes
03	s	uhm sir ... uhm sir ... with number 9 you said the domains were ...
04		negative two, two and four ... and it ... and it was a function
05	t	yes
06	s	but I don't understand that
07	t	what don't you understand
08		you tell me what you don't understand instead of
09	s	.....(interrupted)..... I don't understand how ...
10		negative two and two ... like how you crossed them off over there ...
11		and four are like equal
12	t	who said they were equal
13	s	or like they come together
14	t	I said ... that that was the domain
15	s	yeah sir that's what I'm talking about
16	t	yeah well the domain is the x values
17		and they are negative two two and four
18	s	.....(interrupted).....yeah ... yeah but
19		I don't understand how they equal
20		they uhm ... they're the same numbers as the func as the range
21	t	who said that they're the same values as the range?
22		the range is ... one, zero and ... one
((Lines 23-35 involve another student distracting the teacher for about 20 secs.))		
36	s	sir I just don't understand
37	t	..... I think that what you don't understand is (interrupted)
38	s	like negative two, two four
39	t	you don't understand what function is ... do you?
40	s	no
41	t	no ... well I think that ... you're probably one of about ten or fifteen
42		in the class that don't understand what a function is

43		and I think that probably at this stage ... you might have to come and 44 see me ... some other time because I can't make it any plainer
45		than what we've done there can I?
46	s	no
47	t	no

The student, Bret, began the exchange by raising his hand to ask a question. This was the normal and appropriate manner in which students engaged in classroom talk in Ivor's class. Bret indicated that he did not understand how it was determined that the relation in Problem 9 was a function. The teacher, Ivor, could have replied simply with , "what don't you understand", but went on with a restating of this in Line 08, " you tell me what you don't understand". There was stress upon the words "you" and "what". The intonation in Ivor's voice gave an overall effect of a mixture of challenge and incredulity. Bret reacts to this by cutting off the teacher's utterance in Line 09 by a rapidly spoken restatement of "I don't understand" followed by specific details of what he doesn't understand. Bret refers to something Ivor had written on the chalkboard. Ivor quickly catches Bret up in an apparent error, Line 11, "four are like equal". Ivor's "who said they were equal" is spoken with unmistakable sarcasm. Bret reacted to this with a meek and almost unhearable, "or like they come together". This was a quick attempt to restate Line 13 in different words, that Bret hoped would be closer to the right answer. Rather than responding to the content of Bret's second attempt, Ivor, with great stress upon "said", restated what he had said previously when working the problem out on the chalkboard. The intonation carries the voice of teacher authority that leaves no room for argument from students. Ivor was making it clear that this was what he had said and there would be no misquoting of it. In Line 15, Bret wisely did not contend with this. He very cleverly, however, employed a strategy of claiming that, although he did not use those exact words, that is what he had been trying to say before. Ivor went on to give details about the domain of the x values, but Bret chose to interrupt him in Line 18. Bret now made a statement, "I don't understand how they equal", that put him back in front of the teacher's verbal firing squad. He restated the content of Line 11, the very words to which the teacher had previously reacted to with such sarcasm and

authority. Ivor allowed him to continue, uninterrupted, and Bret was thus allowed to come one step closer to explaining what it was he didn't understand. He extended the equal notion to the range instead of the domain this time. The teacher now used a parallel grammatical construction with identical intonation here as he did in reacting to the idea that the x values were equal in the domain, only this time the range was being discussed.

This has turned out to be a fairly lengthy dialogue between Bret and Ivor, and the stress under which the student was operating was apparent to the whole class. There was a timely distraction at this point, provided by one of Bret's fellow classmates. It would be conjectural to claim that this student intentionally dropped a piece of chalk next to his desk in order to distract the teacher from his verbal dual with Bret. Suffice it to say, that this incident did provide a twenty second break in that dialogue.

In the pause after the chalk incident, the lesson could certainly have taken off in a new direction. The fact that Bret, in Line 36, reopened his problem of not understanding is evidence that there was a degree of genuiness and urgency from his standpoint to try to grapple with this idea of recognising functions from consideration of the domain and range of x values. This time, however, Bret is not allowed to go very far. Ivor interrupts Bret's "sir I just don't understand" with his own "I think that what you don't understand". Ivor told Bret what he didn't understand, again in the authoritative teacher's voice in Line 37. The intonation chosen by the teacher left Bret no room to contend. When asked, "do you", at the end, Bret meekly and quietly said, "no", he did not understand what a function was. The teacher, emphasised this by restating Bret's no with an emphatic no in line 41 with a dramatic pause of four seconds after this to let the enormity of this soak in to Bret and the rest of the class. Ivor then went on to make it clear that Bret was not alone, that in fact probably half of the class did not understand the basics of what a function was. He finished with "I can't make it any plainer .... can I", and Bret meekly agreed, "no". There was irony in this, in that Bret was no closer to understanding Problem 9 now than he was when he had asked for help at the start of this excerpt. What Bret had wanted to say was that he did not

understand how to determine if an equation was a function, because he did not understand the details of how to investigate the domain and range of x values to see if they met the criteria for a function. Instead of helping Bret with such details, the teacher had missed an opportunity to clear up a basic gap in student knowledge, and glossed over the problem with the more global, and pedagogically less than useful conclusion that Bret could not do Problem 9 because he could not do it!

Establishment of teacher authority over students was accomplished by three main strategies: parallel grammatical construction; stress on key words; intonation. The teacher often used the strategy of interrupting the student to establish that he had control of classroom discourse. The sudden takeover of the student's turn at talk was an exercise of power by the teacher. The typical student response to this was to allow the teacher to successfully do so by not contending the takeover. Although students rarely challenged the teacher's authority to control the discourse in this manner, they often used clever strategies to sidestep it somewhat. For example, in this excerpt, Bret was not intimidated by the teacher's parallel grammatical construction of "who said", showing persistence in continuing to state, "sir I just don't understand". This is an example of the student employing a similar strategy (parallel grammatical construction) to attain his objective, namely to get the teacher to acknowledge that there was a student who did not understand a point in the lesson. It is clear, that in Ivor's class there was struggle for power and authority between the students and the teacher. There was an obvious element of contestation and reciprocality.

In comparison to the above example, we will now look at an excerpt from Northside School. This excerpt took place about five minutes into the day's lesson.

01	t	if we have the same x value ... we must have the same y value ...
02		otherwise it's not a function ... Carla?
03	s	what if the y value has more than one x value
04	t	that's alright ... doesn't matter if the y value is repeated ...
05		as long as the x ... if the y value's repeated ... as long as it's right
06		here ...what we the first concern is right ... number one is the is the x
07		value ... check your x values ... and see if they are different ...
08		if they are different ... it's a function ...

09 if we have something to repeat ... then what we have to do ... is check
10 the y values ... then we check the y value ... so if x is repeated ...
11 then the y has to be repeated ... if the y isn't repeated ...
12 if it's repeated it's okay ... if they are <u>not</u> repeated ... then it's not a
13 function ... that's some of the things ...that we were doing yesterday...
14 and I think some of you might have been confused ...
15 so let's have a look at that number 9 now
16 is number 9 a function? ... we check the x values ... and we say yes
17 that's fine ... so therefore Tara?
18 s it's a function
19 t it is a function

The teacher, Jeff, defined a practical manner in which students could determine if a relation was a function or not, by matching the x and y values. He did this without mention, at this point, of terms like domain and range. This contrasts with Ivor's frequent use of such terms. Carla asked the first question in Line 03 and the teacher cleared up this potential misunderstanding by reassuring her that this situation was alright and did not affect the interpretation of whether the problem was a function or not.

As the class worked through the homework problems, some students appeared to be getting the idea, as evidenced in Tara and Carla's answers. Jeff's questions required short answers keyed to very specific local cues. For example, in Line 18, Jeff called on Tara, who answered simply, "it's a function". Jeff evaluated the answer as correct by his parallel grammatical construction mimicking the student's construction. This is a strategy that both evaluates and rewards the student's response as a correct one, and also rebroadcasts it to the whole class in a manner meant to emphasise it. This is a much different motivation for the use of parallel grammatical construction than that used by Ivor.

Students in Jeff's class appeared to be confident to provide short simple answers to specific questions. There was a noticeable lack of terminology employed by both teacher and students. In contrast to Ivor's class, there was rarely much wait time between Jeff's question and a student response.

This excerpt is illustrative of the data in general, in that there was a matter-of-fact, simplistic approach to instruction in Jeff's class. This was reflected in even intonation contours and very little argumentative dialogue between teacher and students. There was little use of stressing key words by Jeff. His intonation was very level and unaccented. This contrasts with Ivor's classroom, in which argument seemed to move the dialogue along. The most noticeable contrast in the two classrooms was the amount of time students talked in dialogues. Student's in Ivor's class tended to talk for longer periods of time compared to Jeff's. There was more interaction between teacher and students in Ivor's class in terms of on-going dialogue.

Although both Ivor and Jeff used similar questioning techniques in their teaching, the tenor of discourse in both classes differed widely. The teachers expressed beliefs in the nature of their students' abilities had consequences on the mode of classroom discourse in the two classrooms. Ivor expected that his students possessed high ability and motivation. These students can and should take responsibility for their own learning. Moreover, as boys, he believed they are not to be dealt with as great sensitivity. Ivor employed sarcasm and argument to move the discourse along, arguably at the expense of coming to grips with the nature of student misunderstanding. He expected that his students were intelligent enough to eventually learn things in time without his needing to slow the lesson down and explain in more detail. In contrast, Jeff constructed his students as less able and of needing more teacher assistance and reinforcement. He used a slower, more pedantic approach to explanation in his classroom. His tone was very even, definitely not sarcastic or argumentative. He did not challenge students who responded incorrectly, but generally supplied the correct answer and moved along to another example. He did this until correct answers started to come in from his students. Thus, the mode of interaction in both classes illustrate how mathematics classroom can be environments that construct active males pursuing understanding and passive females following rules.

CONCLUSIONS

Three types of conclusions can be drawn from the above analysis. Firstly, conclusions from the findings that resulted from analysing the corpus of data itself. Next, methodological conclusions with respect to the design of the study, in particular with respect to the usefulness of classroom observations to study social context. Finally, conclusions about the benefits of alloying a social critical conceptualisation of the study with a sociolinguistic methodology of analysis.

Conclusions from the Data

Comparison of the context of discourse of mathematics in the two classrooms showed that even though the teachers and students were engaged in working from the same textbook, the actualised curriculum was quite different in both classes. One classroom was developing mathematics as a highly formal field of study, stressing mathematical structures, concepts and language, the second class was developing mathematics as a set of skills or rules. The first class stressed meanings and reasons while the second class stressed generalisations of pattern from within mathematics itself. Further students in one class were encouraged to be self reliant in checking their progress and to be participants in their development of mathematics ideas, while the second class, indirectly encouraged the dependence on the teacher as a source of knowledge and assessment. Using the sociolinguistic terms adopted in this analysis the two classes differed in the field and tenor of discourse.

The linguistic concepts of register and dialect may be used to discuss the significance of these differences. Halliday and Hassan (1989) defined the concept of register as a "configuration of meanings that are typically associated with a particular situational configuration of field, mode, and tenor" (p. 38-39). In discussing the sociolinguistic aspects of mathematics education, Halliday (1978) stated that "it is the meanings, including the styles of meaning and modes of argument, that constitute a register, rather than the words and structures as such" (p. 195). A dialect, on the other

hand, was defined as "a variety of language according to the user [or a group of users]" (p. 41). Such differences could be social or geographic in origin. Dialects were saying the same thing differently and registers were saying different things (See Halliday & Hassan, 1989, page 43). Whether the variations observed here constituted different registers or different dialects, is a question that can be answered by more micro linguistic analysis. Of interest to this study was that the mathematical register had different manifestations in the two classes. Further, these alternative manifestations did not have the same social value. One manifestation was perceived as appropriate for students intending to go into higher education and useful for making scientific and business decisions, while the second was perceived as appropriate for the "less able" students and appropriate for market transactions. If research in the area of language and mathematics is to provide useful information about the development of mathematical understanding in children, then, inevitably, it has to address the question of value.

The second conclusion from the above analysis is related to the contradictions that teachers face in the conduct of their work. These contradictions are not caused by lack of knowledge or skill in the teachers, or from inconsistencies in their views. On the contrary, they arise because of teachers, awareness of the context of their teaching. They are contradictions, inherent in the system of values of the school and society, which defines teachers work.

School mathematics, probably more than any other subject, is used by society for the stratification of students according to ability, and for access to higher education with all the associated privileges. Moreover, teachers are aware that the content of many school mathematics programs is selective and values the mathematics that is thought to be formal and abstract. Teachers face a dilemma of either teaching this valued mathematics to all students, irrespective of their ability, interests or mode of thinking, and hence doom some to failure, or to modify the mathematics to suit the needs and abilities of the students, and hence, limit the access of these students to higher studies.

Further, teachers perceive the official curriculum as imposing restrictions on the content and style of teaching. Teachers encounter prescribed syllabus as a series of

topics to be covered. They are aware that these topics require time to develop and are given priority over more open ended mathematical investigations, based on everyday student experiences, that may be more immediately useful and enjoyable to students. Even the most liberal and progressive teacher faces a day-to-day battle to achieve a balance between the content prescribed by the curriculum and the other type of mathematics that may be very individualistic, informal and context dependent.

The third contradiction faced by teachers is related to the gender and socioeconomic background of students. The differences observed in the classroom interactions may be partially related to the individual characteristics of the teachers involved. However, both teachers were aware that their behaviour with students, to a certain degree, was a function of the gender of the students. Further, both teachers perceived that the socioeconomic background of the students was important determiner of the motivation of these students to succeed in school mathematics. Similarly, the two teachers had different views about the students ability and aspirations for higher education. This study has shown that teacher behaviour in the respective classrooms was consistent with the views that the teachers held. Progressive and liberal educational principles, that dominate teacher training programs, necessitate the modification of the curriculum according to the needs and interests of the student. Yet this modification "May ... reinforce different learning style and student self perceptions and ultimately maximise differences in student achievement" (Leder, 1987, pp. 268-269). Further, progressive education encourages the treatment of students with respect and politeness at all times. In the context of these two classes, at least, we have seen that sarcasm in one classroom may have been effective in building ties and some sense of reciprocity between students and the teacher and that care and support in the second classroom may have contributed to an atmosphere of dependence and reinforcing perceptions of human fragility.

The concern about these contradictions in the classroom stems from the particular conception of the social context adopted in this project. The human agency here is not conceived as a given entity, rather as a social construct. This view of the

human subject is consistent with the concern expressed by Walkerdine (1990) who "proposed a theory of practice in which, instead of a unitary fixed of human subject possessing skills in contexts, linked to models of learning and transfer, we might understand subjectivity itself as located in practices, examining the discursive and signifying methods through which a person becomes 'subjected' in each practice" (p. 51).

Use of Classroom Observations

Since the sixties, the social critical perspective has provided valuable insights into the role that schools play in social reproduction within society. More recent contributions within that approach, which evolved from ethnographic investigations into actual school culture (Willis, 1977), provided greater insight into the mediation of social values and introduced concepts of resistance, penetration and contradictions. This project carries these methods a step further into the actual classroom. The assumption was that our understanding of the processes of mediation of culture and forms of resistance may benefit from this closer view.

Classroom observations have contributed to our understanding of the social context of mathematics education in at least three ways. First, it allowed the chance to see how teacher beliefs and perceptions are reflected in the practice of teaching. The aim was not to look for inconsistencies between belief and practice, but to investigate the mechanism by which these beliefs are translated into practice. Secondly, this closer look allowed us to study how teachers modify the curriculum to meet the perceived needs and abilities of their students, and how it is possible for different contexts to follow same prescribed syllabus and construct different curricula. Thirdly, these observations allowed the investigation of the contradictions that exist in the classroom and forms of resistance that students engage in. Further, it raised the possibility that the perception of girls as obedient and co-operative may discourage them from engaging in contestation and resistance. This interest in forms of contradictions and resistance is more than a mere theoretical interest. These forms of resistance and contradictions may

prove to be valuable basis for developing counter-hegemonic practices in education. At this stage of the development of the Social Context Project, these issues have not been addressed.

Use of the Social Critical and Sociolinguistic Perspectives

The Social context project was conceived from within the social critical sociology perspective. It adopted the ethnographic methods of data collection, including interviews and classroom observations. The social critical sociology provided the conceptual tools for analysing the data, but not the practical tools to deal with the huge amount of data gathered. The Functional Theory of Language is a sociolinguistic theory that provides a view of language use that is sympathetic with the social context views adopted by this project, and has provided a framework for dealing with the classroom observations. This analysis illustrates the benefit obtained of using both perspectives in an attempt to make sense of the data. Naturally not all the constructs of that theory were used. Our interest in looking at the role of language in this project is a social context one and not a pure linguistic one. Other investigations into the role of language of mathematics and in constructing understanding may make use of other aspects of this theory.

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